

## FINAL REPORT

January 28, 1996

ONR Award No. N00014-91-J-1682

Title: "An Investigation of the Sources and Characteristics of the Noise  
Component in SeaMarc II Echo Signals"

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### INTRODUCTION

As is well known, the SeaMarc II towfish system was lost at sea during a scientific survey cruise in the Southern Ocean near the beginning of this project.

Work was immediately begun on the design and construction of a replacement mapping system to be called HAWAII MR1. The signal processing for this system was designed based on the crude and incomplete information obtained earlier from one short series of noise measurements that had been made on SeaMarc II with experimental modifications. In the new MR1 system, the recorded signal consisted of digital, complex samples of the acoustic echo (i.e. in-phase and quadrature components, referenced to transmitter sinusoidal waveform). The entire duration of the echo signal was recorded, including the entire water-column reverberation and the subsequent sea-floor echoes, usually out to 70 - 80 degrees incidence angle.

### NATURE OF THE WORK

Further noise analyses were carried out during the design and test of the new MR1 system, and also during the initial survey work with this new instrument. Results and conclusions are summarized below.

#### Highlights of the MR1 Analysis and Research Work:

1. During several of the cruises in deep water, we measured the echoes from the Deep Scattering Layer, including its diurnal movement from shallow to deep water and return. It was observed to be a major component of the water-column reverberation, when it was present. Further measurements could be undertaken to produce useful data in understanding the density, composition variation, and behavior of this feature of the deep ocean.
2. Noise bursts of unknown origin were often observed in the water column, occasionally with phase-difference characteristics that mimicked rapidly-rising or -diving sources. If there were similar noise bursts after the start of the true sea floor echo, they would have been undetectable in that strong-signal regime. The



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2. Please contact me if you require additional information. My e-mail is *silverr@onr.navy.mil* and my phone is (206) 625-3196.

  
ROBERT J. SILVERMAN



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January 29, 1996

Scientific Officer Code: 1125GG  
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Dear Sir,

Enclosed please find 3 copies of the Final Technical Report for Grant No. N00014-91-J-1682.

I appreciate the support provided to my ongoing research work by both the Grant and your own direct interest. I look forward to our future interaction.

Sincerely,

Stanley H. Zisk  
Planetary Scientist

cc:

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source of these reflections was never pinpointed; sea life, or rapidly-rising bubbles of unspecified origin, are two possible explanations that do not conflict with the observations.

3. Bathymetry computer algorithms had been designed (based on work with SeaMarc II data) to process the entire echo signal as complex numbers, rather than separate phase (for bathymetry) and amplitude (for side-scan) analyses. The selection of this technique was confirmed by the observations. The phase of the individual data samples (before processing) showed in general (but see below) a consistent dependence on the sea floor bathymetry, as was desired and expected, when the amplitude was strong, but became more and more random as the amplitude became weaker. This was only one of several reasons for integrating the signal to improve the S/N ratio.

4. It was observed that echo amplitude depended, as expected, on the usual factors of the range to, and the acoustic parameters of, the sea floor reflecting surface. In addition, however, there was observed the randomizing "speckle" typical for any narrow-bandwidth wave-propagating system. The group of micro-elements that made up each measured pixel of the sea floor was reflecting the incident acoustic wave each with its own phase but arbitrary amplitude. When these micro-reflections were summed and became the measured samples, the sample amplitudes would be randomly distributed, even for a strongly-reflecting area. Thus, there were always some samples observed to have very low amplitudes, and hence phase differences that were not a measure of the bathymetry of the sea floor but rather were noise-generated. The only way to determine the true bathymetry of any point, then, was to perform a statistical average of the signal to remove the effects of speckle. And, since there was only one measurement of each sample, the summing of adjacent samples was the only available averaging technique, which had the unfortunate result of unavoidably degrading the resolution of the final data map.

5. A most interesting observation was the extreme variation in the observed strength of the "first-return" echo, that initial part of the signal generated at essentially vertical incidence. As a true specular reflection, that would be predicted from simple considerations to be by far the strongest part of the reflection, partly because of the reflection geometry and partly because the "pixel" size is so large and the phase across the pixel so uniform that the "speckle" randomness would be minimized. However, it is well known from radar analysis that the strength of the near-vertical reflection is strongly dependent on the roughness of the local topography, as well as (in acoustics) the ratio in acoustic impedance between the sea floor material just below the reflecting boundary and the water column just above it. The observed variation in this reflectivity might well be used as a quantitative measure of the local variations in small-scale morphology and acoustic impedance of the sea floor along the track of the survey vessel.

#### PERTINENT PUBLICATIONS

Masnadi-Shirazi, M.A., de Moustier, C., Cervenka, P., and Zisk, S.H., "Differential Phase Estimation with the SeaMARC II Bathymetric Sidescan Sonar System" IEEE Journal of Oceanic Engineering 17, 3, 239-251 (July 1992).

Shor, A.N., M. R. Rognstad, and S. H. Zisk, "HAWAII MR1: A New Tool for Mapping in the EEZ", Proceedings of the Pacific Congress on Marine Science and Technology (1992)..

Zisk, S.H., R.B. Davis, C. de Moustier, and J. Hughes Clark, "Signal Processing and Noise Sources in the HAWAII MR1 Bathymetric Sonar Mapping System", AGU 1992 Fall Meeting (poster).

Edwards, M., A.N. Shor, M. Rognstad, S.H. Zisk, M.J. Simpson, and R.B. Davis, "HAWAII MR1: A New Tool for Mapping and Analyzing Seafloor Terrain", 29th International Geological Congress, Kyoto, Japan (24 August - 3 Sept. 1992).

Halter, E.F., A. N. Shor, S. H. Zisk and M. R. Rognstad "HAWAII MR1 and SEAMAP: Two New Systems for Sea Floor Surveying", AGU 1992 Fall Meeting (poster).

Shor, A.N., M.R. Rognstad, and S.H. Zisk HAWAII MR1: "A NEW TOOL FOR MAPPING IN THE DEEP OCEAN", 1992 AGU Ocean Sciences Meeting.

Zisk, S.H., A. Shor, M. Edwards, and M. Rognstad, "HAWAII MR1: Regional-Scale Mapping for the ARSRP Natural Lab", Acoustic Reverberation Special Research Program Research Symposium, Scripps Institute of Oceanography, 7-9 April 1992.

Edwards, M.H. and S.H. Zisk, "Shore-Based Post-Processing of ARSRP HAWAII MR1 Data", Acoustic Reverberation Special Research Program Research Symposium, Woods Hole Oceanographic Institute, 18-20 Nov. 1992.

Davis, R.B., M.H. Edwards, S.H. Zisk, A.N. Shor, E. Halter "New Techniques for Interactively Processing and Mosaicking Various Bathymetric and Backscatter Datasets", EOS, Trans. Am. Geophys. Union, 74, 306, 1993.